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Ultrasonic/Sonic Driller/Corer (USDC) as a Sampler for Future Planetary Exploration Missions

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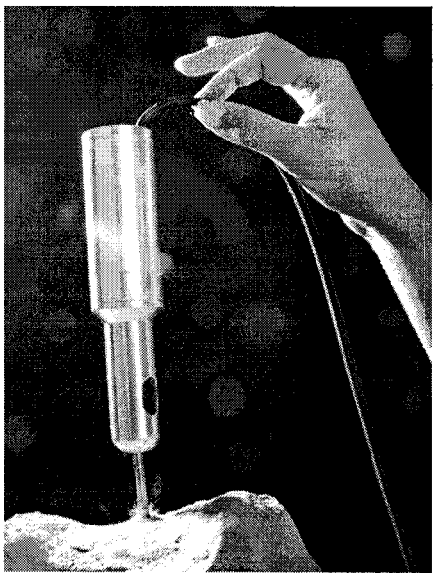

Future NASA exploration missions to Mars, Europa, Titan, comets and asteroids are expected to perform sampling, in-situ analysis and possibly return of material to Earth for further tests. One of the major limitations of sampling on Mars and low gravity environments is the high axial force required by conventional drills. An ultrasonic/sonic drilling/coring (USDC) mechanism developed by JPL and Cybersonics Inc addresses these and other limitations of conventional drills.

The USDC is lightweight (450 g), requires low preload (< 5N) and can be driven at low power (<5W). The device can drill 50 mm diameter holes in rocks with various levels of hardness including granite, diorite, basalt and limestone. USDC employs an ultrasonic horn that is driven by a piezoelectric stack. The horn drives a free mass that resonates between the horn and drill stem. The hammering action involved with the coring process can produce cores of various shapes, which need not necessarily be round.

USDC is highly tolerant of changes in its operating environment. Because is it driven by piezoelectric ceramics, USDC can be designed to operate at a wide range of temperatures including those expected on Mars(-60C) and Venus (+400C). The coring bit creates a hole that is slightly larger than the drill bit diameter. This latter reduces the chances of bit jamming if the integrity of the hole is maintained, thus avoiding another problem associated with conventional drilling. The ultrasonic bit need not be sharp thus it does not have problems with bit dulling and wear. USDC is a novel device, not a conventional ultrasonic drill. Although the drill is driven electrically at 20 kHz a substantial sub-harmonic acoustic component is found that is crucial to drilling performance. An analytical model has been developed to explain this low frequency coupling in the horn, free mass behavior, drill stem, and rock interaction.